MANAGING URBAN WATER SYSTEMS WITH SIGNIFICANT ADAPTATION DEFICITS – UNIFIED FRAMEWORK FOR SECONDARY CITIES: PART II - THE PRACTICE

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Abstract

Adaptation gaps are shortcomings of a system responding to climate change, whereas adaptation deficits are shortcomings providing services. These two drivers for adaptation are often in conflict in many secondary cities in the global south (SCGS). It is possible to align these seemingly conflicting drivers into a productive unity, a conceptual alignment, which is the first step in achieving harmony while implementing adaptation actions. This paper focuses on the practical aspects of implementing aligned adaptation action that leads to improvements in liveability, sustainability and resilience of SCGS. At an abstract level, the nature of the adaptation problem is similar to the complex problems identified in various domains, such as software development, manufacturing and supply-chain management. The widely accepted 'agile principles' – used in the above domains – is the basis for developing a set of twelve principles for urban adaptation, which are synthesised from numerous recent studies that have implicitly proposed or applied most of these principles to climate change adaptation in urban settings. These principles lead into four essential objectives appertaining to the process of sustainable urban adaptation. The urban agile principles are used to analyse the current state of adaptation of Can Tho City in Vietnam and to ascertain the agile ways of addressing its adaptation challenges. Analysis of the outcomes show that harmonized approaches can simultaneously address both adaptation deficits and gaps.

1. Introduction

Cities have started addressing their needs to improve their liveability, sustainability and resilience. It is instructive to harmonize the often disconnected views on adaptation gap, adaptation deficit and the corresponding adaptation actions needed to close the gaps between these while addressing these needs of the cities. Adaptation deficit is the difference between the current state of a system and a state that minimizes adverse impacts from existing external (e.g. climate) and internal (e.g. urban development driven) forcings (Burton 2004; Pathirana et al. 2017). The difference between any pre-agreed adaptation target (adaptation need) and the actual or anticipated state of adaptation is defined as the 'adaptation gap' (UNEP 2014). Predominantly, adaptation deficits look at the current state of affairs while the adaptation gap looks at the (medium and long-term) future (Burton 2004; Pathirana et al. 2017).

Burton (2004) discusses two types of adaptation actions: Type I adaptation, the everyday adaptation to weather and climate that has always been a feature of human life; and Type II adaptation, the adaptation to (climate) change usually as mandated under the UN Framework

Convention on Climate Change (UNFCCC). Type I adaptation is promoted as part of sustainable development, while Type II adaptation relates to anthropogenic climate change and is driven by rules and practices like those set out in the Convention. Hence it can be stated that Type I and Type II adaptation actions are those that are geared towards addressing adaptation deficits and adaptation gaps respectively.

Harmonizing Type I and Type II adaptation actions is important for all urban environments. However, it is imperative in the adaptation process of secondary cities, the rapidly developing cities and with a population less than five million, in the global south (SCGS), largely due to the existence of significant adaptation deficits. Pathirana et al. (2017) have presented a conceptual framework – unified framework for adaptation – for harmonising Type I and Type II adaptation actions. The unified framework for adaptation brings together Type I and Type II adaptation actions in the context of (i) enhancing liveability in current situations; (ii) satisfying the demand due to short- term and medium term urban growth; (iii) ensuring sustainability of adaptation actions; and (iv) changing perceptions about adaptability among different stakeholders.

In this paper we propose practical guidelines, recommend structures and processes to apply the framework into practice. The hypothesis presented in this paper is that the 'agile principles' that are used in domains like software development to address the combined challenges of high uncertainty and high urgency can be utilised successfully to harmonize Type I and Type II adaptation of urban water systems. Agility in this context can be defined as the ability of the city to adapt quickly to the changes. The newly developed urban agile principles have been used to analyse the current state of adaptation of Can Tho City in Vietnam and to ascertain the agile ways of addressing its adaptation challenges. The relevance of the urban agile principles for SCGS in general is presented as synthesis and conclusion.

2. Background

Adaptation in general, especially urban adaptation, has to address the three inter-related challenges, namely: a) uncertainty; b) path dependency[1]; and c) ensuring sustainability and liveability. These three challenges are closely related to addressing the adaptation gap (Pathirana et al. 2017). However a fourth challenge arises while addressing the adaptation needs in SCGS, which is the need for strengthening basic infrastructure due to significant adaptation deficits. Significant deficits include: (i) lack of basic infrastructure (water supply, sanitation, roads, solid waste management etc.); and, (ii) lack of infrastructure to meet the increasing demand due the the growth of these cities, which increases the adaptation deficits over time.

The approach to adaptation implicitly embraced by decision makers and many stakeholders in SCGS is often sequential: (i) the adaptation deficit is addressed first by improving infrastructure; and (ii) once the deficit is reduced, adaptation gap is reduced. In other words, first address Type I adaptation and then move on to Type II. The sequential approach has two major weaknesses: a) Considering the significant adaptation deficits in SCGS (and the rapidly changing nature of stakeholder expectations), it is unlikely that they can be closed in a short

[1] Path dependency is the causal dependence of a decision on past decisions. For example some types of Sustainable Drainage Systems (e.g. detention storage) will depend on the separation of storm water and sewage. Historical decision to have a combined sewer system has major implications on how these will be implemented in today's context.

time period; b) Important opportunities for addressing issues arising from uncertainty, path dependency and the need for sustainability are lost by following a sequential approach.

The worldview that is promoted by many scientists, even by international donors and central governments, is one that largely focuses on adaptation gaps related to climate change (e.g. IPCC (2014)). With justifiable scientific reasons, these key players attempt to promote the anticipation and addressing of medium and long-term consequences of global climate change. Understanding the need for climate adaptation research, many research donors rightfully make funds available for research in the domain. The sole promotion of the need to address adaptation-gaps often creates situations where the adaptation research ignores the adaptation-deficits (Type I) in contexts such as SCGS (e.g. UNEP (2014)). This can lead to the rejection or neglecting of Type II adaptation research outputs by authorities in-charge of urban development and many other locally relevant stakeholders.

In SCGS, a better approach is to consider Type I and Type II adaptation needs rather than to promote one or the other of these 'adaptation camps'. Integrative views are necessary to understand and appreciate any complex problem and to form realistic solutions and the management and adaptation of urban water systems is no exception (e.g. Allen et al. (2016)). Type I and Type II adaptation need to be integrated in projects in order to improve efficiency and sustainability. However, there are serious pitfalls to be avoided when following the path of integration in proposing and implementing adaptation responses. The pitfalls are (i) emergent complexity; and (ii) interconnectedness of the main and associated problems.. City managers invariably favour 'transparent' information and struggle with complexity and the models that go with it (e.g. Hurley et al. (2008)). City managers, while appreciating the nuances of complex solutions, shy-away from them and move on with over-simplistic, traditional and sequential, approaches to address problems of what they see as 'real-world', i.e. they take a heuristic stance based on 'what-we-always-do'. In essence, the call for an integrative view often backfires, forcing city managers to largely treat the discourse as a theoretical one with little immediate practical value. Hence the challenge in applying the unified adaptation framework is ensuring that there is a practical plan of action that is (i) inclusive enough in-terms of representing reality; and,(ii) integrative. The plan of action should be straightforward and prescriptive enough to be of use to both the decision makers and practitioners– not a trivial feat.

We call here for the better alignment of Type I and Type II adaptation into a synergetic, cohesive and directed strategy, albeit with the caveat that implementation should not become 'lost' by being too well embedded; just as sustainability has virtually everywhere, and policy based climate changed adaptation in some cases (Chu et al. 2015). It is also recognised that the complete integration of climate adaptation issues with urban issues might lead to loss of momentum regarding tackling climate challenges and adequately dedicated attention (Chu et al. 2015). Hence the focus should be on harmonising the measures used to address Type I and Type II adaptation and not complete integration.

2.1. Addressing urgency and uncertainty in urban adaptation

Recent studies have emphasized the importance of inclusivity, integration and flexibility in the context of urban adaptation (Aerts et al. 2014; Allen et al. 2016; Birkmann et al. 2012; Chu et al. 2015; Garschagen 2014; Gersonius et al. 2012a; Klijn et al. 2015; Roberts 2014; Rogers et al. 2012; Spiller et al. 2015; UNEP 2014) For example, Gersonius et al. (2012b) emphasizes the importance of 'mainstreaming' adaptation action as an 'opportunistic' approach for implementation, which properly applied, can help harmonize Type I and Type II adaptation. For example, suppose there is a major attempt to upgrade the sewer system of a city. This is a

Type I adaptation action. Integrating flexible components that can be later upgraded as needed (e.g. Green infrastructure, such as swales) in response to future changes is a way to reduce path dependency in addressing future uncertainty (Ashley et al. 2016). Flexible components and portfolios of measures can provide a cost-effective way of sustaining the possibilities for addressing uncertain climate-induced pressures in the future, by integrating Type II adaptation with Type I actions.

The need to address adaptation deficits is usually urgent, but has only a moderate degree of associated uncertainty (Point B in Figure 1a) as current demands are relatively well known. Nonetheless projecting future from current demands always has a moderate degree of associated uncertainty. Whereas, adaptation gaps are characterized by a very high degree of uncertainty and a moderate degree of urgency (Point A in Figure 1a). Current demands to address these are small, but there are very high (*a priori* unknown) future demands with very high associated uncertainty. In SCGS, there is the need to successfully integrate or harmonise Type I and Type II adaptation measures in order to ensure the affordability, success and sustainability of the measures arising from adaptive actions. The combination is therefore a state that is both highly urgent and highly uncertain (Point C in Figure 1a). Integrated projects that address both Type I and Type II needs have a high urgency due to the large adaptation deficits to be addressed now and also high uncertainty due to the unknown future adaptation gaps.

2.2. Agile Principles

Addressing the combination of high uncertainty and high urgency is not a challenge that is novel or specific to the domain of urban water management. Similar challenges have been faced during the last several decades by, amongst others, manufacturing and Software development industries (Bernardes and Hanna 2009; Koste and Malhotra 1999; McGaughey 1999; Sánchez and Pérez 2005). Businesses and organizations such as these face a volatile environment that is highly uncertain with challenges such as increased competition, globalized markets, technology obsolescence and individual customer requirements. The uncertainties, the existential threat to survival and need for the maximisation of profits has necessitated an urgent shift of paradigm from traditional 'predictive' planning to a newer 'agile' or adaptive planning paradigm (Wendler 2013). This is illustrated in Fig 1b. Agility and agile manufacturing has been used for example by the US automotive industry to counter rigidity in manufacturing through the introduction of response buffers, postponing decisions in manufacturing and late configuring of products (Holweg 2005). Many new product industrial development software projects routinely apply agile methodologies that were originally formulated in the 1990s (Kettunen 2009).

The agility of an enterprise is defined as its ability to quickly respond to unexpected changes in order to survive unprecedented threats by proactively seizing opportunities. An agile approach may be illustrated using a number of principles, although the concept can be loosely defined as a process where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams, promoted by adaptive planning, evolutionary development, early delivery, continuous improvement, and encouraging rapid and flexible responses to change (Fowler and Highsmith 2001; Leffingwell 2010). Therefore an agile process is one that has a high capacity to adapt to change (Pressman 2005). It encourages moving from a 'waterfall' approach to a cyclic approach of change, where development is done in a number of, 'tight' cycles, each spanning a short amount of time/effort (Figure 1(c) and (d)). This generates flexibility and allows for effective learning. The 'agile manifesto', that is

prevalent in the software domain (Fowler and Highsmith 2001) and its twelve guiding principles such as continuous service delivery, welcoming change, maintaining simplicity, frequent updates, continuous engagement with stakeholders and sustainability presented in Table 1 have been derived from Beck et al. (2001).

2.3. Agility principles in Urban Development

Recent literature setting out frameworks for adaption has (implicitly) included many of the proposed agile principles for urban adaptation. Table 1 also lists the components of agility found in the select urban adaptation frameworks reviewed. It can be seen that there is some congruity in each of the agility principles from the manufacturing sector when considered in the context of urban (climate) adaptation. As indicated in Table 1, many frameworks/methods have implicitly included a number of the principles. Chu et al. (2015) include most of these principles in the context of promoting public participation and facilitation of engagement of different civil society actors in adaptation planning and implementation. The inclusion of most components of the agility principles by Chu et al. (2015) is due to the inclusivity approach – as a means of stakeholder involvement and sustaining continuity in adaptation processes, based on a consideration of adaptation planning and implementation in two cities: Quito in Ecuador and Surat in India. These cities pursued two different inclusivity approaches such as broader inclusion and selective targeting of stakeholders respectively. Hence it has been concluded that the features of the agile approach advocated by the agility manifesto (Beck et al. 2001), are relevant to the domain of adaptation. The broad agile objectives of the manifesto that are applicable to agile urban adaption and considered in this paper are given below.

1. A strong emphasis on stakeholders involvement: Processes and tools are secondary and are seen as a means of achieving proper stakeholder communication and representation of ideas.
2. Stakeholders do not have a ‘blueprint’ for the ideal product. Blueprint evolves as the stakeholders collaborate through close, frequent communication and working in teams.
3. There is a ‘working product’ from the early stages of development (e.g. stakeholders do not have to wait for a distant future to witness the working product). The early prototype is, albeit a limited, works and is usable. This ‘working state’ is maintained throughout the subsequent development stages without a special emphasis on a ‘final’ product.

These features arise from embracing the complexity, uncertainty and urgency of the problem while at the same time using collaboration and respecting the needs and wishes of all stakeholders as a means of overcoming the challenges faced.

We propose here that a potential application of agile principles is in the context of urban adaptation: The conditions pertaining to the imperative uncertainty and urgency, Point C in Figure 1a , are similar between manufacturing needs and that of responding to climate and other urban system changes, hence the enabling mechanisms could be of a similar nature (Column 3 of Table 1). The potential for application of agile principles considered here is wider than the need to address urgency and uncertainty in urban adaptation for climate change alone.

On a cautionary note, the industrial systems such as automobile manufacturing, aerospace and nuclear energy systems which are “complicated systems”, are different from urban water management systems, which are “complex” systems (Dunn et al. 2016). Application of complicated system principles such as agility principles to urban development needs therefore to align various components of the urban system and harmonise adaptation by understanding

the known relationships of what is a complex urban system. The other area of distinction between the domains is in the scope of the outcomes between manufacturing and adapting urban areas. In the former, the aim is to produce goods and profit from sales, whereas, in a fair society, the aim of urban adaptation is to ensure the health, welfare and well-being of the urban population and environment. Municipalities typically oversee this task, although in recent times the private provision of public 'goods' has complicated this picture and profits may also be linked to the core services required of society, including urban water.

However, as application is in its infancy, these differences may not be a limitation to the use of manufacturing developed agile principles in the urban domain and will only be properly tested once there have been a number of applications. Also, it is useful to align or actively seek out the objectives of agile urban adaptation with the agile manufacturing frameworks in order to facilitate the application.

2.4. Essential objectives and practical principles for agile urban adaptation

Definitive quantification of various aspects of the medium and long term future of SCGS is not possible. The usual approach of aligning policy along a 'most-plausible' or 'most obvious' (i.e., business-as-usual e.g. Ashley et al. (2016)), single solution is not always useful... The adaptation challenge in SCGS is to reduce the lock-in or path dependency, which is due to the business-as-usual approach, as much as possible without excessive financial burden or loss of immediate utility. Further, the involvement of all the stakeholders, though complex, is likely to increase acceptability and sustainability of adaptation responses, contributing towards value creation.

Though it could be seen that the agility principles from manufacturing are valid with regard to urban adaptation and urban agile principles can be formulated (column 1-3, Table 1), it is essential to identify specific planning objectives in the urban adaptation context, that could be used in materialising / operationalising urban agility. The essential objectives of agile urban adaptation have been deduced from the existing urban adaptation frameworks (Refer column 2, Table 1) using agile manifesto and principles (Beck et al. 2001) as a guideline. The essential objectives of urban adaptation constitute: (i) flexibility – to tackle uncertainty and path dependency (Gersonius et al. 2013); (ii) plausible scenarios – to ensure liveability and sustainability under all potential futures (Brown et al. 2009); (iii) Type I and Type II adaptation - aligning and harmonising type I and type II adaptation (Burton 2004; Pathirana et al. Accepted); (iv) stakeholder consultations – views from all the stakeholders are paramount and continuous learning is achieved through engagement at every state of adaptation, such as in learning and action alliances (Ashley et al. 2012; Cettner et al. 2014) . The collection of practical objectives should encompass all of the requirements expressed by the twelve agility principles (Refer to the grouping of agile urban principles based on the essential urban objectives in column 4, Table 1). These outline what should be the essential objectives of a viable urban adaptation system.

The prevalence of agility principles or the four agile objectives (A-D in column 4 of Table 1) in the current urban adaptation context is most apparent when considering SCGS. As an example, Can Tho city in Vietnam is undergoing climate and socio-economic adaptation and has been selected as a case study city to review the application of agility principles and identification of agile urban adaptation objectives. The various adaptation aspects in Can Tho have been assessed using the principles and the four objectives of a proposed agile adaptation framework. Can Tho case study should not be seen in the view of operationalising or applying

the agility principles in adaptation planning. The case study illustrates where the agile objectives are identified in an ongoing adaptation planning process. The implementation issues and other practical difficulties in operationalising agility principles in urban adaptation is work under progress and will be reported in a follow up article.

3. Case Study

Can Tho is an SCGS and the largest and a fast growing secondary city in the Mekong Delta, Vietnam. The city is affected by drivers such as (i) sea level rise, driven by climate change; (ii) change in river runoff, due to climate and hydrologic change; (iii) change in urban runoff, due to imperviousness growth and enhancement of extreme rainfall due to urban growth driven micro climate; (iv) socio-economic drivers such as population growth, spatial planning and economic growth rates (Huong and Pathirana 2013; MDP 2013; SCE 2013). However, there is uncertainty with regard to climate and socio economic drivers. Assessment of proposed urban development and adaptation responses –such as new ring dikes, improvements to roads – show that the adaptation responses, which are path dependent and address only the current adaptation deficit, are not sustainable in the face of swift and uncertain future change (SCE 2013). Can Tho was selected as the case study city as it is a secondary city with Type I and Type II adaptation needs and the authors have a good understanding of adaptation needs as they have been working with this city on various adaptation projects.

Increased in-migration and unaffordable real estate prices have meant that a section of the population has settled alongside rivers and canals thereby making themselves vulnerable to pluvial and fluvial flooding due to both an infrastructure deficit and change in climate (Garschagen 2014; Quan et al. 2014). Can Tho is adapting to climate change as well as the socio-economic changes and to a certain extent is still adapting to the political changes after the Indochina wars, a series of wars fought in the region between the years 1946 to 1989 (Garschagen 2014; World Bank 2014). Hence Can Tho provides an opportunity to review the application of the agility principles for urban adaptation. We have evaluated the current status of adaptation planning and processes in Can Tho against the four main objectives of the proposed agility framework (Table 1). In the following discussion each of the twelve agile principles listed in Table 1 are referred to as '[Px]' where x is the number given to the principle in Table 1. The relevance of agile urban principles and agile urban objectives in Can Tho are summarised in Table 2.

3.1. Are there generally accepted 'virtual-worlds'?

Studies on Can Tho residents' vulnerabilities, adaptation to climate change (Garschagen 2014) and proposed dike system (Pham et al. 2009) are available. Radhakrishnan et al. (Under Review) for example, combine global and local understandings of climate change and socio economic change to estimate the enhancements to adaptation pathways for the planned flood protection systems in Can Tho due to enhancements in the coping capacity of the citizens. The recent Mekong Delta Plan presents four different regional development paths based on climate change, urban development and industrialization (MDP 2013). There are a number of modelling studies of varying degrees of complexity and integration (Huong and Pathirana 2013; Quan et al. 2014; Radhakrishnan et al. Under Review), although there is no general acceptance among stakeholders which models ('virtual worlds') to use to explore the various scenarios (Table 2).

The lack of an accepted set of 'virtual worlds' has resulted in a lack of common understanding of the various adaption issues and outcomes among different stakeholders[P3]. While attempts are being made in the context of a number of training and information sharing initiatives by

different projects, considerable work has yet to be done to clarify both the issues and the potential responses available in Can Tho.

3.2.Equal importance for Type I and Type II adaptation

Some of the current adaptation measures such as dike heightening to overcome the adaptation gap in Can Tho have been found to be effective only for a short time into the future (Radhakrishnan et al. Under Review). Many of the current and planned Type I and Type II adaptation measures for climate change and socio economic change are also not compatible (Pathirana et al. Accepted). There are proposals (PM 2013) for the socio-economic development and poverty reduction of Can Tho which project the plans as inclusive, pro-poor and delivering social justice. Measures such as: (i) The relocation of vulnerable households to reduce exposure to floods – which are not effective in Can Tho as residents will not move as there is a fear of loss of income due to the relocation; (ii) The possibility of elevating the houses in-situ – which depends not only on needs due to past occurrences of flooding but also on the economics of individual households and any savings available for self-financing (Garschagen 2014). The type II adaptation measures such as dike heightening that are being planned are based on the historical river water levels along with allowances for climate forcings such as sea level rise (eg. SCE (2013)). These do not account adequately for uncertainties and are not flexible in nature and therefore are of high risk. Type I and II adaptation measures are also being promoted separately by different stakeholders and interest groups and there are major differences of opinion amongst these on the relative importance of the various measures proposed (Table 2). Hence the present value of adaption action is not well reflected in the adaptation plans [P5] and equal importance is not given to Type I and Type II adaptation [P6].

3.3.Lack of flexibility and value from the proposed adaptation measures

The current measures addressing Type I and II adaptation in Can Tho are not flexible (Pathirana et al. Accepted; Radhakrishnan et al. Under Review). However, there is scope for incorporating flexibility measures in dikes to tackle uncertainty against sea level rise and how this could be achieved has been demonstrated for Can Tho (Radhakrishnan et al. Under Review). Looking at these measures from a flexibility point of view can open opportunities for simultaneously achieving type I and type II adaptation goals as well as securing other multiple benefits [P1]. There is a considerable scope for improving the potential (macro-) economic benefits of adaptation projects by looking at the opportunities for multiple benefits [P2]. Currently this is an area which is largely neglected in Can Tho (as in many other SCGS). For example, Quan et al. (2014) demonstrated that there is scope for addressing adaptation gaps in an urban development project with the dual objectives of poverty alleviation and beautification around the Xan Thoi lake in An Cu district, Can Tho (Table 2). However, the necessary alignment of adaptation actions for this requires sustained involvement of stakeholders and a general methodology that accepts and includes engagement from all the stakeholders at all stages of adaptation, for example using learning and action alliances (cf. Ashley et al. (2012)).

3.4.Stakeholders working together

A number of stakeholders such as the Department of Planning and Infrastructure (DPI), Department of Labour, Invalids and Social Affairs (DOLISA), Ministry of Agriculture and Rural Development (MARD), Ministry of Natural Resources and Environment (MONRE), Can Tho Climate Change and Coordination Office (CCCO) are working on aspects that are addressing the adaptation deficits and gaps in Can Tho, i.e., [P7] and [P8] (Clemens et al. 2014; Garschagen 2014). The organizational setup at the higher levels of government and at grassroots level seems to provide a means for involvement via stakeholder meetings, the promotion of leadership and a flow of information at some levels (Clemens et al. 2014). However, there is rarely any common understanding or agreement between these stakeholder

communities about the adaptation issues such as: i) the acknowledgement that climate adaptation and socio economic adaptation are occurring in parallel, resulting in uncoordinated planning and implementation by DOLISA, MONRE and MARD; ii) adaptation is an environmental issue that may conflict with economic development, which subsequently results in protectionism separating the perspectives of MONRE and MARD (Garschagen 2014); iii) local communities feeling that lower-tier stakeholder aspirations and options do not reach the higher levels of government (Garschagen 2014; Moench et al. 2011). Numerous research projects have organized seminars and workshops with representation from other cities within Vietnam and overseas, so that the city managers could learn from the global experience. The ideas expressed as 'City to city learning' (Zevenbergen et al. 2015) are gaining acceptance in Can Tho. From the above narrative it is clearly evident that [P9], [P10] and [P11] are not being included effectively in Can Tho (Table 2).

4. Synthesis

It is clear that many of the objectives necessary for effective agile adaptation, such as a common understanding of adaptation, mechanisms for stakeholder involvement and champions are not yet available (Table 2) in Can Tho. Many SCGS – such as Byblos in Lebanon, Porto Alegre in Brazil, Semarang in Indonesia – face the same situation (100 Resilient Cities 2017). This study has identified that Can Tho has the potential for developing an agile, learning and dynamic stakeholder community and many of the key components for this such as Type I and II adaptation needs, adaptation plans with potential for flexibility, aspirations among stakeholders to cooperate are in place (Table 2). The current challenges are to: (a) create an enabling institutional and governance environment that promotes these potentials and: (b) integrate the various elements together in a viable fashion.

Can tho city has significant capacity gaps in terms of adaptation. Although there is an understanding of climate issues, there is a lack of shared knowledge about adaptation measures, interest and capacity for learning. There are few if any, practical avenues for knowledge pooling and discussion although there is a central coordinating office for climate change CCCO (Garschagen 2014; Moench et al. 2011). There are numerous initiatives often associated with research projects, with the objective of enabling information sharing, collaboration and promoting inter-sectoral coordination. However, these attempts are diffuse and are yet to reach the critical mass and inertia needed to be effective.

The analysis presented here has revealed the benefits of applying the agility principles to understand the limitations of the adaptation landscape in Can Tho as a typical SCGS. The agile adaptation principles can be applied to align adaptation measures, harmonize multiple needs, and bring about organisational integration and synchronization at multiple levels. This includes households, district, city, provincial and national levels and coordination across agencies such as DOLISA, MARD and MONRE to better understand, plan and implement adaptation measures.

Although agility principles are demonstrated here as being applicable in the context of SCGS in Can Tho, these are likely to be applicable in a city in a developed or industrialised country as such cities are also undergoing significant change in the context of increasing resilience, sustainability, liveability, transformation and productivity. Rapid change can create situations with large adaptation deficits even in these cities.

An argument against the application of agility principles is the observation that urban adaptation context is far more complicated compared with the original domains the agility

principles were borrowed from. Urban adaptation plans are: (i) often outdated by the time they are ready to be implemented; either due to adaptation deficits or changes in external stressors (Pathirana et al. Accepted; Radhakrishnan et al. Under Review); (ii) susceptible to manipulation by political decisions and the purchaser – provider relationship between e.g. international development banks and national governments (Cettner et al. 2014; Poustie et al. 2016). However, in spite of these added challenges, adaptation in urban areas needs to: address path dependencies, adhere to principles of sustainability and importantly, pursue the improvement of liveability by addressing adaptation deficits. Urban adaptation needs include the essential traits of agile systems such as the changing dynamics between the system components and the continuously evolving ways in which the objectives such as liveability are addressed. Hence application of agile principles is recommended as a useful framework for formulating urban adaptation responses.

Transformational adaptation is the way of using behaviour and technology to change biophysical, social or economic components of a system fundamentally (EEA 2016). Urban adaptation provides opportunities for incremental and transformative development trajectories, where there is an integration of knowledge into decision making, building on exchange among policy makers, scientists and those at risk; designed and modified to the local needs and capacities; ensuring plan and policy continuity; promoting ownership and equity (Chu et al. 2015; Revi et al. 2014). The application of agile principles to urban adaptation is proposed here as a practical way to operationalize transformational urban adaptation.

5. Conclusion

Approaches to adaptation to climate and societal changes are typically fragmented into two often not connected types: Type I - adaptation deficits; Type II - adaptation gaps. This fragmentation is inefficient, likely to lead to extra costs and potentially ineffective responses. Urban adaptation is necessarily a complex problem exemplified by the combined realities of high uncertainty and extreme urgency to act. At the same time the pitfall of inaction due to unmanageable complexity needs to be avoided. The traditional predictive approach of understanding the problem and then designing and planning solutions for the long-term often fail in SCGS. We believe that a set of strategies similar to the proposed framework of using agility needs to be utilized to harmonise urban adaptation. Many fields that are far removed from urban adaptation have faced similar challenges of having to address urgent, but poorly-understood problems. Here we have utilised the experiences from information technology and automotive sector in resolving uncertain and urgent urban adaptation challenges.

Addressing the various adaptation needs by harmonizing processes for synchronisation of the ways of dealing with adaptation deficits and gaps is essential, especially in the Secondary Cities in the Global South (SCGS). Pathirana et al. (Accepted) set out a proposed conceptual framework to address the challenge of harmonizing these adaptation deficits and gaps whereas in the current paper a set of agile principles and objectives are set out that can help identify and address shortcomings in the adaptation responses of urban areas. This can direct efforts to harmonize approaches to simultaneously address both adaptation deficits and gaps.

By adapting ‘agile’ approaches the challenges exemplified by the combination of high-uncertainty/high-urgency has been addressed here by encompassing the complexity arising from inclusion of multiple players, drivers and scenarios. Based on the well-established ‘twelve principles of agile software development’, we have proposed an equivalent set of principles for urban adaptation (Table 1). Review of selected recent literature related to urban adaptation shows that similar ideas are being promoted in many discussions on urban adaptation (Table

1). Here these established principles of agility have been interpreted into twelve guiding principles for application in adaptation planning. Further we propose four important objectives of urban adaptation – flexible incremental solutions; common understanding (i.e. through virtual worlds); equal importance to adaptation gaps and adaptation deficits; and stakeholders working together - that will help bring these principles into action. We have shown in a case study of adaptation in Can Tho, Vietnam that the agility approach, derived from manufacturing and software industries, is applicable to urban area adaptation.

The principles and objectives set out here should only be seen as the first steps towards a verifiable approach that can only be achieved from further application and experience.

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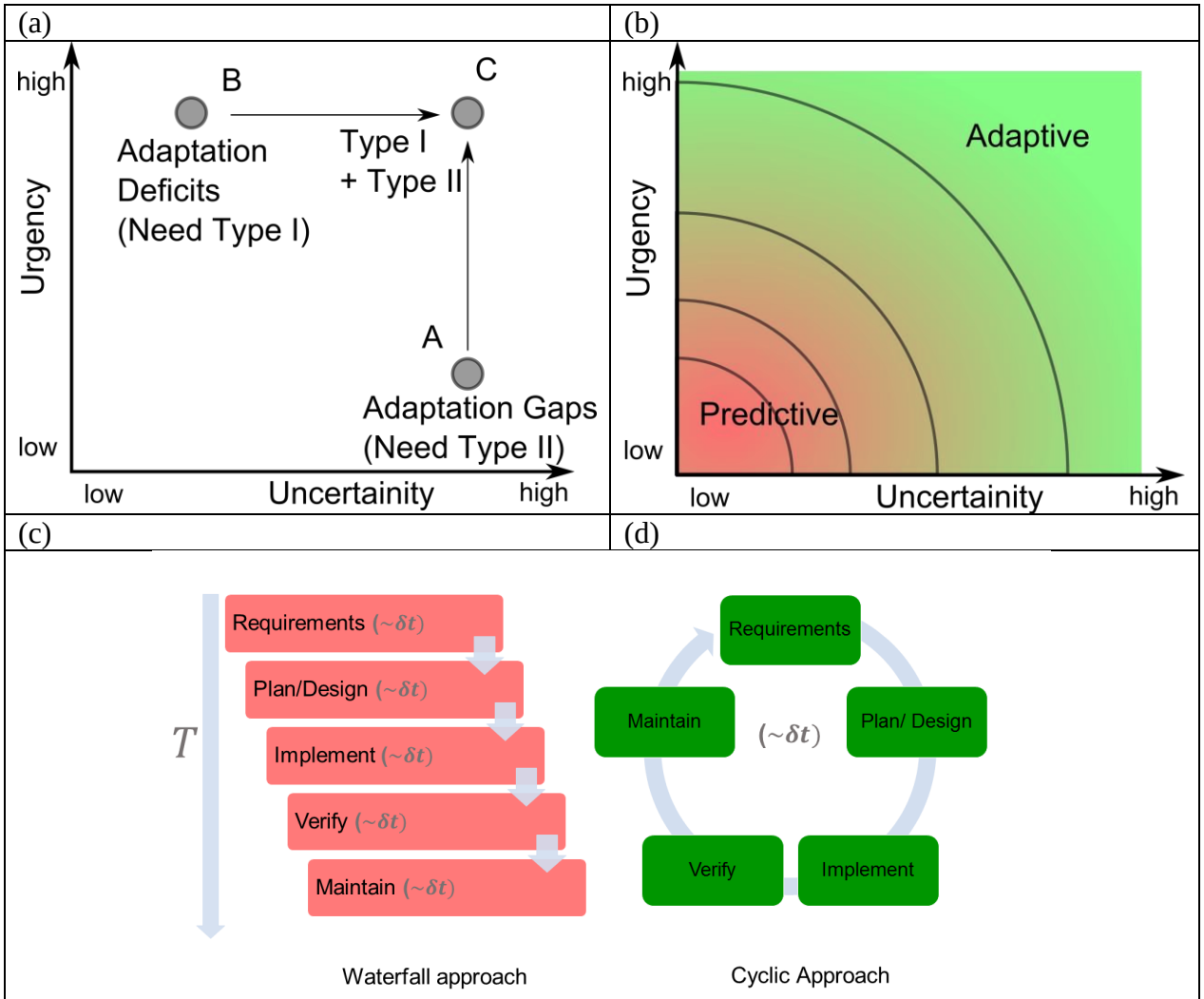

Figure 1: Top: (a): Integrating adaptation deficits and gaps creates a situation that is both highly urgent and highly uncertain. (b) Moving from "predictive development" to "adaptive (agile) development" was the solution that worked in the domain of software development (after Chang (2010)). Such shift of approach will also imply moving from a 'waterfall' approach (c) to a cycle approach (d), where development is done in a number of, 'tight' cycles, each spanning a short amount of time/effort (in the order of $\delta t \ll T$ where T is the typical design horizon (say about 40-100 years for urban systems, and several years for software). δt can span between a few months to several years in case of infrastructure project (in software development it is typically a few days or weeks) Cyclic development allows for flexibility as well as learning by doing.

Table 1 Agile manifesto, agile principles for urban adaptation, essential objectives for agile urban adaptation and its relevance

Agile Manifesto for Software Development (Fowler and Highsmith (2001); Beck et.al (2001))	Relevant existing urban climate adaptation frameworks (Literature review)														Principles (Agile) for urban adaptation (Our interpretation)	Essential objectives for agile urban adaptation (What urban agile principles mean in practice)
	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.	☑	☑	☑			☑	☑	☑	☑	☑	☑		☑	☑	1. Highest goal in urban development should be to enhance liveability, sustainability and resilience of urban communities, according to those communities' evolving aspirations.	**A. Favour flexible, incremental, changeable, multi-value solutions** a. While not always possible, make every attempt to propose adaptation measures that can be implemented incrementally – ideally at time-steps of several years. At every stage the solution should have utility. b. Favour solutions that result in as little path-dependency and lock-in as possible. c. Financial evaluation of measures should take into account the multiple-benefits of solutions, not only of the delivery of the main objective.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.		☑				☑	☑				☑		☑		2. The aspirations of the stakeholders do (and should) evolve. Harness these changing aspirations and be ready to accommodate them, rather than attempting to resist them.	

Agile Manifesto for Software Development (Fowler and Highsmith (2001); Beck et.al (2001))	Relevant existing urban climate adaptation frameworks (Literature review)														Principles (Agile) for urban adaptation (Our interpretation)	Essential objectives for agile urban adaptation (What urban agile principles mean in practice)
	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
3. Continuous attention to technical excellence and good design enhances agility.			☑	☑	☑			☑	☑			☑			3. Consensus is not a license to do away with planning and engineering. Introduce planning and engineering to all the stakeholders. Focus on developing capacity of all stakeholders in the elements of planning and engineering necessary for meaningful contribution.	**B. Virtual-worlds, understood and accepted by all stakeholders** a. Comprehensive but easy to use modelling systems are essential. In the case of adaptation work, this is probably the only practical way to objectively test various proposed measures. The objective of the modelling systems is not to predict a single plausible future, but provide a platform to test variety of proposed measures against wide-range of scenarios. b. The modelling system should have trust, acceptance and agreement of all stakeholders. c. The modelling system should be routinely updated to incorporate new knowledge, and conditions, to address missing requirements. d. The modelling system should
4. Simplicity--the art of maximizing the amount of work not done--is essential.		☑	☑					☑	☑	☑					4. Simple solutions are often the best. They are often easier to perceive, implement, manage and maintain.	

Agile Manifesto for Software Development (Fowler and Highsmith (2001); Beck et.al (2001))	Relevant existing urban climate adaptation frameworks (Literature review)														Principles (Agile) for urban adaptation (Our interpretation)	Essential objectives for agile urban adaptation (What urban agile principles mean in practice)
	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
																encourage experimentation with range of measures. It should never be a hindrance for testing measures. Sometimes it is needed to sacrifice complexity (resulting in slow response or user-unfriendliness) for utility.
5. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.		☑				☑						☑		☑	5. All adaptation solutions should have a value today, in order for them to be socially relevant.	**C. Type I and II adaptations are equally important.** a. Use today's requirements as starting points in evolving measures for addressing short, medium and long-term adaptation needs. b. Look for solutions that address both adaptation-deficits and adaptation-gaps. c. All solutions – even longer-term – should also have an immediate utility.
6. Working software is the primary measure of progress.		☑	☑			☑	☑		☑			☑	☑	☑	6. Never disengage the adaptation from regular urban development process. Look for opportunities for mainstreaming adaptation.	

Agile Manifesto for Software Development (Fowler and Highsmith (2001); Beck et.al (2001))	Relevant existing urban climate adaptation frameworks (Literature review)														Principles (Agile) for urban adaptation (Our interpretation)	Essential objectives for agile urban adaptation (What urban agile principles mean in practice)
	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
7. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.		☑	☑										☑		7. Done right, stakeholder groups and governance structures never become irrelevant, they should/can evolve and continue sustainably.	**D. All stakeholders working and learning together:** a. Promote leadership b. Organize city to city learning c. All stakeholders are important: Scientists are not first among equals . Stakeholders should also include users or clients of the system, e.g. citizen groups, business interests. Ideally these clients should be given the (informed – see f) leadership in the process of adaptation. d. Organize frequent stakeholder meetings. Physical meetings cannot always be replaced by teleconferences. In urban context this should be easy to facilitate. e. Use group-planning sessions effectively. Encourage all stakeholders (not only planners) to participate as equals. Use expertise of each constituent member only as a resource, not
8. Business people and developers must work together daily throughout the project.	☑	☑					☑			☑			☑		8. All stakeholder groups should participate in decision making from day one, all stakeholders should take shared ownership of decisions.	
9. Build projects around motivated individuals.	☑	☑													9. Champions are indispensable: Identify them, empower them and help them flourish.	

Agile Manifesto for Software Development (Fowler and Highsmith (2001); Beck et.al (2001))	Relevant existing urban climate adaptation frameworks (Literature review)														Principles (Agile) for urban adaptation (Our interpretation)	Essential objectives for agile urban adaptation (What urban agile principles mean in practice)
	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
Give them the environment and support they need, and trust them to get the job done.																as a license for that member to monopolize the views related to the domain. f. Quickly fill the knowledge-gaps of all stakeholders by providing appropriate learning opportunities (includes targeted trainings). g. Documentation of all important stakeholder activities is essential. Use easy-to-use modern collaboration platforms (e.g. wiki's) with version controls to achieve this. Try to make documentation an integral part of stakeholder activities
10. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.	☑	☑		☑			☑								10. A community of practice of all stakeholders should meet physically, frequently. The collaboration needs a strong platform; it also needs objective means of testing and benchmarking diverse ideas against all conceivable scenarios.	
11. The best architectures, requirements, and designs emerge from self-	☑	☑									☑				11. Properly guided, self-organizing stakeholder groups can often come with better solutions than a pre-prescribed plan. More importantly, they	

Agile Manifesto for Software Development (Fowler and Highsmith (2001); Beck et.al (2001))	Relevant existing urban climate adaptation frameworks (Literature review)														Principles (Agile) for urban adaptation (Our interpretation)	Essential objectives for agile urban adaptation (What urban agile principles mean in practice)
	a	b	c	d	e	f	g	h	i	j	k	l	m	n		
organizing teams.															encourage shared ownership of decisions.	
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.	☑	☑									☑				12. Self-reflection of all stakeholders and the stakeholder group in-general helps in maintaining their relevance and effectiveness over time. City to city learning can be useful in this process.	

Relevant existing urban climate adaptation frameworks – review of existing literature on recent climate and urban adaptation

[a] Urban climate resilience framework (Tyler and Moench 2012)
[b] Inclusive approaches to urban climate adaptation planning and implementation in the global south (Chu et al. 2015)
[c] Urban futures methodology (Rogers et al. 2012)
[d] Methodology for local economic impact assessment of climate change (Hallegatte et al. 2011)
[e] Adaptive flood risk management planning (Klijn et al. 2015)
[f] Framing the adaptation Gap (UNEP 2014)
[g] Unified conceptual framework for Adaptation (Pathirana et al. Accepted)

[h] Design alternatives for flexibility (Spiller et al. 2015)
[i] Flood resilience strategies for coastal cities (Aerts et al. 2014)
[j] Framework for scope and scale of secondary cities (Roberts 2014)
[k] Integrated framework for vulnerability and adaptation analysis (Birkmann et al. 2012; Garschagen 2014)
[l] Flexible adaptive strategy (Gersonius et al. 2013; Gersonius et al. 2012b)
[m] Strategic flood risk management (Sayers et al. 2015)
[n] Urban infrastructure appraisal (Young and Hall 2015)

Table 2: Scoping for urban agile principles and identification of agile adaption objectives in Can Tho

Essential agile objectives in Can Tho (Refer to Table 1 for description on objectives and principles)	Urban agility principles needed in Can Tho
The current adaptation measures that are being planned and implemented in Can Tho are not flexible and do not have multiple value, but there is scope for flexibility and multiple benefits (Urban agile objective A - Favour flexible, incremental, changeable, multi-value solutions- comprising principles P1, P2)	The current proposals address the resilience component and liveability component separately and not together. The sustainability components are not clearly reflected in the adaptation and urban development plans.
	The change in aspirations of people are not reflected in the plan but there is scope for inclusion.
In Can Tho, it can be seen that there are multiple virtual worlds - various engineering, planning and socio economic models - but there is a lack of common understanding. (Urban agile objective B - Virtual-worlds, understood and accepted by all stakeholders - comprising principles P3, P4)	Periodic attention is paid towards technical excellence of design standard such as flood protection (e.g. SCE 2013) However, the efforts do not encompass all key stakeholders
	Many solutions are sector-based, making them not-simple, but complex to maintain and integrate with overall development of the city
Type I and Type II adaptation needs are clearly seen in Can Tho, although the focus there seems to be more on Type II	Present benefits of future adaptation requirements is not clear in the adaptation plans proposed. Most of these plans talk about present costs and future benefits.

Essential agile objectives in Can Tho (Refer to Table 1 for description on objectives and principles)	Urban agility principles needed in Can Tho
adaptation. This could be due to the interest or agenda of international donors in Can Tho. (Urban agile objective C - Type I and II adaptations are equally important - comprising principles P5, P6)	Satisfying the current urban development needs through adaptation plans is not being done, although there is scope for this (e.g. Quan et al. (2014))
Although a number of stakeholders are involved in the adaption planning of Can Tho, there has not been any significant effort put towards learning and working together. There is plenty of scope for it and it is being explored through capacity building workshops and city to city learning networks. (Urban agile objective D - All stakeholders working and learning together - comprising principles P7, P8,P9,P10,P11,P12)	Can Tho is still undergoing evolution in governance due to the change in status from a city to a city state. The aspirations of the people are also evolving as seen in the rise of middle class and in the perceptions' about adapting to floods. Refer to Garschagen (2014)
	Although there is interest among the diverse group of participants towards participation and to take ownership of decisions, there are no platforms to do this and there are social barriers hindering equal participation.
	Involvement of champions in adaptation issues are not clearly evident in Can Tho. However, the need for champions and their involvement is being encouraged through multi-stakeholder workshops (e.g. Radhakrishnan (2015)).
	Meeting of all stakeholders is not yet common. When this happens, the interactions can be too rigidly controlled (Clemens et al. 2014)
	Although there is scope for emergence of self-organising stakeholder groups and consultations, it has to be nurtured and guide in the initial states

Essential agile objectives in Can Tho (Refer to Table 1 for description on objectives and principles)	Urban agility principles needed in Can Tho
	The relevance of present and future adaptation plan in Can Tho is yet to emerge through stakeholder consultants although there is scope for this.